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SSME
RELIABILITY PROGRAM PLAN

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(Approved)

Contract NAS8-45000 DPD 341
Data Requirement RA-145-U1

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FOREWORD

This document was prepared by Boeing North American, Rocketdyne, under contract NAS8-45000, to satisfy the requirements of Data Procurement Document 34 1, Data Requirement RA-145-U1. It incorporates the applicable SSME reliability requirements per NASA Handbook, NHB5300.4(1D-2).

ABSTRACT

The Rocketdyne SSME Reliability Program Plan is presented, and activities that apply to the design, development, procurement, fabrication, test, acceptance, maintenance, and use of the SSME, software, and associated Ground Support Equipment (GSE) are described.

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TABLES

FIGURES

ACRONYMS

CAB	Corrective Action Board
CEI	Contract End Item
CIL	Critical Items List
CIS	CIL Implementation System
C of C	Classification of Characteristics
DAR	Deviation Approval Request
DOD	Department of Defense
DR	Data Requirement
ECP	Engineering Change Proposal
EEE	Electrical, Electronic, and Electromechanical
FAR	Failure Analysis Report
FRR	Flight Readiness Review
FSR	Field Site Requirements
FMEA	Failure Mode and Effect Analysis
GFE	Government-Furnished Equipment
GSE	Ground Support Equipment
GIDEP	Government-Industry Data Exchange Program
MCR	Master Change Record
MRD	Material Review Disposition
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NFL	Non-Flight Limitation
PCR	Problem Closure Review
PRAMS	Problem Reporting and Management System
PRB	Problem Review Board
RRM	Rocketdyne Reliability Manual
SSME	Space Shuttle Main Engine
UCR	Unsatisfactory Condition Report

1.0 INTRODUCTION

1D100 SCOPE

This Reliability Program Plan establishes the Rocketdyne commitment to the National Aeronautics and Space Administration (NASA) reliability program requirements. This applies to the SSME, associated Ground Support Equipment (GSE) produced by Rocketdyne, GFE maintained by Rocketdyne Contracts and subcontractors, and suppliers under Rocketdyne's cognizance. The plan and the activities it describes apply to the design, development, procurement, fabrication, test, acceptance, maintenance, and use of SSME hardware, software, and associated GSE.

This plan follows the general format of NHB 5300.4(1D-2); Safety/Reliability/Maintainability and Quality Provisions for the Space Shuttle Program, October 1979, and is sufficiently broad in scope to satisfy the intent of this NASA publication as specified in Chapters 1 and 3. The plan shall be evaluated at least every 12 months and a joint NASA-contractor determination will establish the need for a complete reissue. The plan may be changed only by mutual agreement between the Marshall Space Flight Center (MSFC) and Rocketdyne. Revisions will be accomplished in a timely manner by either individual page issue or by complete reissue. Written NASA approval is required before using this document, including any revisions thereof.

The program has been planned to emphasize proactive elements in accordance with the philosophy of continuous process improvement within the context of overall SSME program objectives. This includes the application of reliability engineering and statistical techniques as the principle means of applying preventative aspects of the program to specific tasks.

In particular, the program employs analyses of the data contained in the Problem Reporting and Management System (PRAMS) database to identify potential problem trends for preventative measures. Design Change Reviews and Trade Studies use Failure Mode and Effect Analysis (FMEA) and Critical Items List (CIL) as a guideline for establishing change requirements. The plan establishes the Rocketdyne commitment to the MSFC Shuttle Element Problem Assessment System for the SSME nonconformance and corrective action reporting.

1D101 RELATION TO OTHER CONTRACT REQUIREMENTS

The Reliability Program Plan is one of several program documents applicable to SSME. These additional plans/procedures are coordinated with SSME Reliability as needed to ensure no conflicts exist with Reliability requirements. The Reliability Program Plan complements and supports the other program elements depicted in Figure l-l.

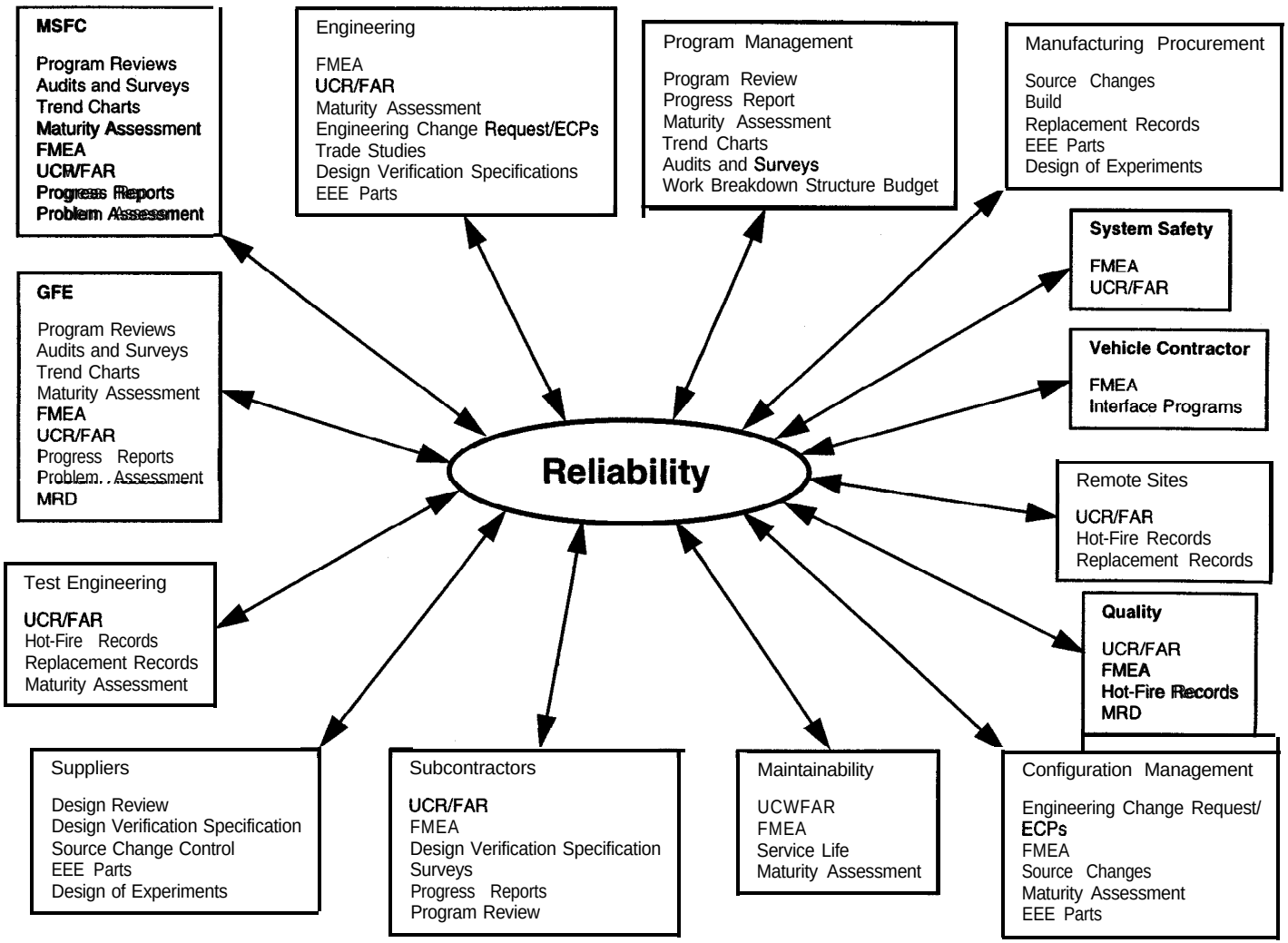

Figure I-l. Reliability Interfaces

lD102 MOTIVATION AND TRAINING

MOTIVATION

1. The identification and correction of document discrepancies (including human errors) is provided through various systems and initiatives. Included among these are Corrective Action Boards (CABs), Problem Closure Review (PCRs), Problem Review Boards (PRBs), and the "Won't Fail" program.

2. Motivational programs are implemented by Rocketdyne's Motivational Coordinator. The program includes:

a. Methods to obtain and distribute Space Shuttle motivation information and materials.

b. Motivational (awareness) indoctrination for contractor Space Shuttle supervisory personnel and work force workmanship.

c. Recognition means for personnel who demonstrate their awareness through exceptional performance.

d. Coordination of subcontractor and supplier motivation (awareness) programs for compliance with the intent of these requirements.

TRAINING

Training of Reliability personnel is augmented by programs such as the Taguchi Methods and "Won't Fail" approach. Additionally, Reliability has found on-the-job training to be an effective tool.

In addition, two Reliability training programs have been established for the SSME Program: the Unsatisfactory Condition Report (UCR) and PRAMS training courses. The UCR training course instructs potential UCR authors in the RF0004-004 Specification requirements and UCR conditions. A list of UCR authors qualified to determine UCR conditions and write UCRs is approved and maintained by Reliability. The PRAMS training course is provided to all UCR and Failure Analysis Report (FAR) authors to assist them in the operation of the PRAMS computer system.

1D103 INDEPENDENT EVALUATIONS FOR NASA

The following actions and prerogatives of the procuring NASA-MSFC installation and its designated representatives are recognized and accepted to examine, evaluate, and inspect all work, data, and documentation generated during the performance of the SSME contract by Rocketdyne and its suppliers.

Rocketdyne and its suppliers, at all tiers, provide full support to these representatives. It is understood that MSFC may utilize portions of the SSME Reliability Program data as input to various government data exchange programs.

lD104 RELIABILITY PROGRAM DOCUMENTS/INFORMATION REQUIREMENTS LIST AND INFORMATION REQUIREMENT DESCRIPTIONS

The formal reliability documents to be submitted for the SSME are listed in Table 1-1. The content, distribution, and frequency of submittal of these documents are as specified in the Data Requirements (DRs.).

Table 1-1. Documents to be Submitted to NASA

DR No.	Document	Frequency of Submittal	NASA Response
RA-145-U1	Reliability Program Plan	Initial, revisions and annual evaluation	Approval
RA-145-l	Reliability Specification	Initial and revisions	Approval
RA- 145-2	Failure Mode and Effects Analysis	Initial and revisions	Approval
RA- 145-9	Critical Items List	Initial and revisions	Approval
MA-076- 1	SSME Monthly Progress Report (Reliability Section)	Monthly	Information

1D105 GLOSSARY OF TERMS

Terminology used in the Reliability Program Plan conforms to the Glossary of Terms provided in Appendix A of NHB 5300.4(1D-2). Acronyms used in this plan are considered as specific only to Rocketdyne (see Acronyms, page iv).

2.0 SAFETY MANAGEMENT

The Reliability Function interfaces with SSME System Safety and satisfies the reliability requirements of the SSME System Safety Program Plan, RSS-8503-8

3.0 RELIABILITY PROGRAM MANAGEMENT

1D300 RELIABILITY MANAGEMENT

Reliability functions are an integral part of the design and development process and include the evaluation of hardware reliability through analysis, review, and assessment. Reliability management provides for timely status reporting to facilitate control of the reliability effort.

1. ORGANIZATION

The SSME program at Rocketdyne continues to be structured along product and support team lines depicted in Figure 3- 1. Each product team has personnel responsible for interfacing with reliability personnel in accordance with the Reliability Program Plan and. subtier procedures (see Section 1D300-2, Reliability Plan Implementation). SSME Reliability, as a separate function, resides within Rocketdyne's Quality Engineering and Technical Support organization.

SSME Reliability is responsible for planning, integrating and managing the overall reliability effort to ensure that the Reliability support function is responsive to the program needs. Reliability Engineering is also responsible for establishing reliability criteria, techniques, and requirements for use on the SSME at Rocketdyne and by subcontractors. SSME Reliability serves as the Rocketdyne contact for MSFC in all reliability activities.

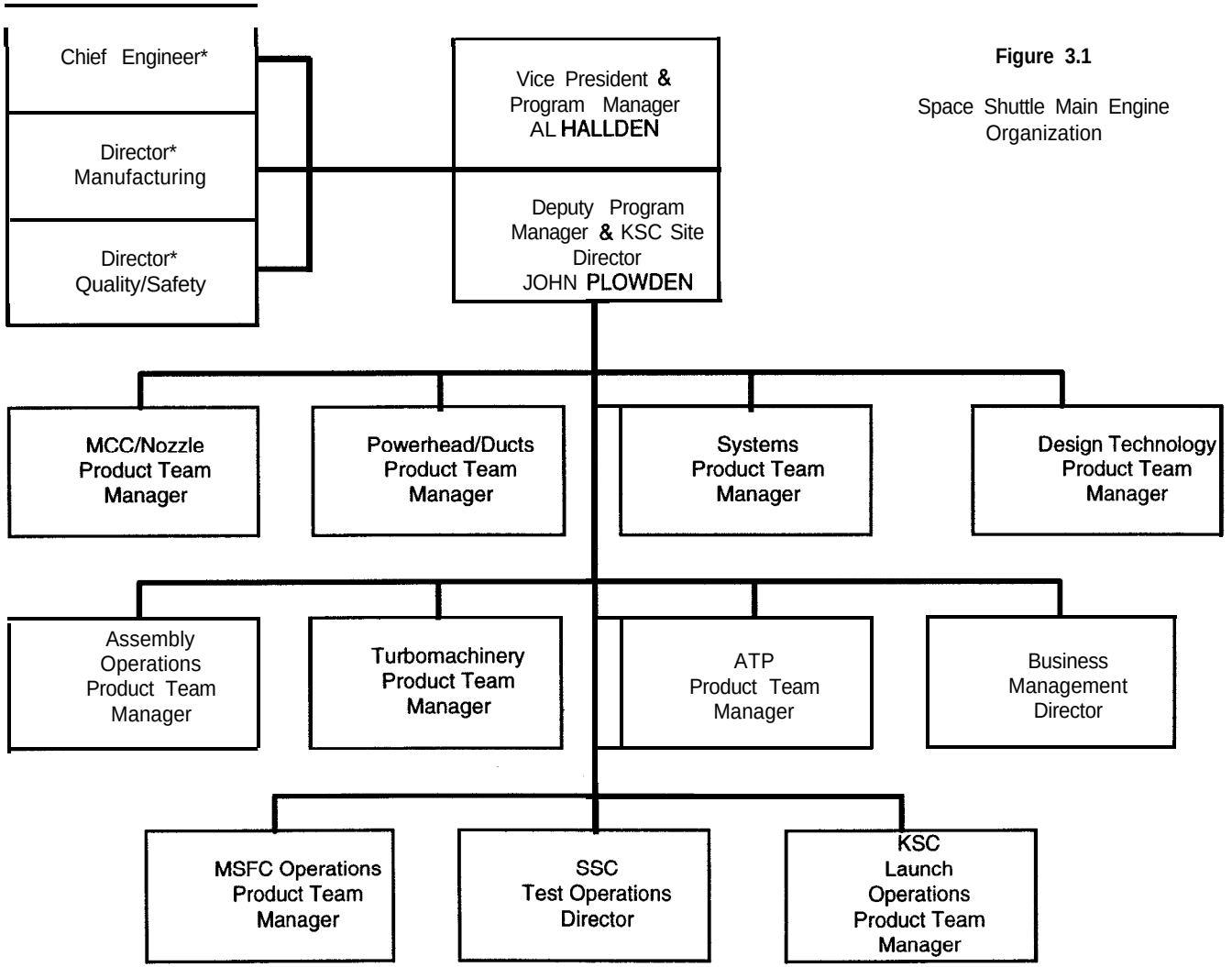

Figure 3.1

Space Shuttle Main Engine Organization

* Functional matrix

2. RELIABILITY PLAN IMPLEMENTATION

a. The Reliability Program Plan is the master planning and control document for defining, implementing, and managing the SSME Reliability Program. Additional details for implementing the plan are contained in the following reliability procedures.

Number	Title
RF0004-004	SSME Reliability Data Reporting Requirements
RRM 3.1	Reliability Charter
RRM 3.2	SSME Reliability Data Evaluation
RRM 3.3	SSME Failure Mode and Effect Analysis and Critical Item List
RRM 3.4	SSME Problem Assessment System Support
RRM 3.19	SSME Reliability Audits
PB96-050	Unsatisfactory Condition Report & Failure Analysis Program
RSOP 13.7	Alert Program (Reference RRM 3.1)

b. Reliability effort at remote SSME test sites is also governed by applicable sections of this overall Reliability Plan. There are no Rocketdyne field sites that require a separate Reliability Program Plan. Requirements in the applicable sections of this document are implemented by procedures generated and maintained at the individual field sites.

3. RELIABILITY AUDITS

Reliability'reviews are conducted in the form of audits and subcontractor surveys, which are conducted to ensure compliance with contractual reliability requirements on Rocketdyne and its subcontractors.

Audits of the Reliability function, including field sites and its interfaces within Rocketdyne, are chaired by the Quality Assurance Internal Audit Functional Director, and supported by Reliability Engineering.

Audit of major subcontractors are conducted every 12 to 24 months, or more **frequently, as determined by performance measurements.**

Reliability performs audits to assure procedural conformance to the Reliability Program Plan.

Results of the audits, including required corrective actions, are documented in a report (narrative letter format) to director-level management and copies are forwarded to the resident MSFC and Defense Plant Representative Office. Action items based on the audit findings are tracked and statused until satisfactorily resolved (i.e, remedial action and recurrence control have been established and properly implemented). MSFC reserves the right to conduct yearly reliability audits of Rocketdyne.

Detailed descriptions regarding both internal and external reliability audits, audit preparation, audit support, and closing of findings and tracking actions are performed in accordance with RRM 3.19.

4. RELIABILITY PROGRESS REPORTING

Reliability progress is reported to MSFC in a monthly reliability engineering study titled SSME Flight Reliability Determination and as a part of the SSME Monthly Progress Report, RSS-8600. The reliability input may include, but is not limited to, information items relating to the UCR/FAR status, engine and component reliability analyses, failure trending, probabilistic risk assessment, and contractual procedure changes where applicable.

Reliability supports SSME program reviews, flight certification reviews, Flight Readiness Reviews (FRR), and internal Rocketdyne briefings to management, by providing Reliability data regarding problem reporting and FMEA/CIL status as required.

5. SUPPLIER RELIABILITY CONTROL

Rocketdyne Reliability requirements are imposed on the major subcontractors and suppliers of parts or components designed and built outside Rocketdyne. After the item has been received by Rocketdyne, all pertinent requirements of this plan continue to apply.

Reliability Program Plans authored by major subcontractors are reviewed by SSME Reliability Engineering for compliance to Rocketdyne's SSME Reliability Program Plan.

Monitoring of subcontractor's reliability performance is accomplished through periodic reports on reliability activities, program reviews, award fees, Rocketdyne surveys, status reports of malfunctions, participation in subcontractor Preliminary Design Reviews, Critical Design Reviews, and technical coordination meetings. Audits are conducted independently or in conjunction with the Supplier Product Integrity Assessment.

Reliability Requirements for Suppliers

a. Applicable Rocketdyne Reliability requirements for parts and components fabricated by Rocketdyne suppliers are defined by the SSME Configuration Management Plan and applicable Rocketdyne System of Procedures (RSOP). These include Specification Control Documents, Source Control Drawings, and Procurement Specifications. These requirements are coordinated by Engineering, Reliability, Procurement, and Quality Assurance.

Reliability reviews and approves Master Change Records (MCRs), applicable Engineering Change Proposals (ECPs) concerning Source Control Drawings, and Material Processes' Approved Source Lists.

Reliability reviews the impact of the source requirements and/or change for impact on such elements including FMEA/CIL, interchangeability, failure history, and reliability degradation.

Changes in manufacturing sources, as required, are subject to approval by the SSME Chief Program Engineer. Significant changes are submitted to, and reviewed by Reliability as well as the members of the Change Control Boards.

Periodic reviews shall be performed by Reliability on failures/UCRs occurring on the SSME to determine if problem areas are attributable to a change in source. Recommendations to add or remove sources from the Source Control system will be made when justified.

b. To support the use of appropriate "off-the-shelf' hardware items and achieve cost-effective procurements, a system for evaluating prospective hardware items is implemented. "Off-the-shelf' hardware is considered when the evaluation disclosed an existing design, previously developed and qualified, that is capable of meeting SSME performance, reliability, safety, and quality requirements.

The reliability evaluation of "off-the-shelf' hardware include the following elements:

(1) Supplier use of controlled parts.
(2) FMEA and other analyses as appropriate, verify design margins and redundancies per Contract End Item specification.
(3) Trade assessment of the relative merits of "off-the-shelf' versus new procurements.

Information derived from these evaluations is utilized to verify compliance with reliability requirements, to assess risk (with the NASA concurrence required when risks have been defined), to develop rationale for acceptance, to establish a baseline for acceptance, and to provide control as a certified item.

The results of the evaluations of these data are documented, and additional controls, as appropriate, are applied to assure the hardware meets applicable reliability requirements as defined by the SSME Configuration Management Plan and RSOP.

6. RELIABILITY OF GOVERNMENT-FURNISHED EQUIPMENT (GFE)

Rocketdyne will satisfy NASA contract requirements relative to reliability, safety, and quality requirements for all GFE. Rocketdyne requires accessibility to all documents (e.g., ECPs, Material Reviews Dispositions [MRDs], Deviation Approval Requests/Non-Flight Limitations [DARs/NFLs], and UCRs) and test data on any GFE that have the potential for impacting SSME interfaces or performance. This information will be utilized to perform as needed analyses regarding:

- Component failure probabilities
- Subsystem failure probabilities
- Manufacturing anomaly trend that may adversely impact SSME reliability
- UCR trend study

Rocketdyne shall be responsible for the identification of the reliability data needed for analysis of GFE. Whereupon examination of this data or testing by the contractor indicates an incompatibility of the reliability of GFE with the reliability requirements of the overall system, NASA shall be formally and promptly notified for appropriate action.

1D301 RELIABILITY ENGINEERING

1. RELIABILITY DESIGN CRITERIA

Rocketdyne's system for evaluating and controlling design changes is described in the Configuration Management Program Plan, RSS-8503-3.

Reliability criteria applicable to the design review program include the practices and procedures employed and a checklist of design aspects to be covered during a design review. Reliability participates in design reviews conducted for both Rocketdyne design hardware and Rocketdyne supplier controlled design hardware. As a minimum these include performance, reliability, critical design, and acceptance test requirements. In addition, major subcontractors are required to have formal reliability program plans.

Factors influencing the reliability of the design are developed as a part of the flowdown of SSME reliability requirements to their respective specification requirements. Reliability provides criteria to the product team's engineering functions for incorporation into the appropriate sections of the SSME hardware specifications. Reliability reviews and approves these specifications for completeness and adequacy of the criteria as a part of the requirements reviews and design reviews. These criteria include factors affecting interchangeability, acceptance testing, failure history, reliability degradation, and life limits. These reviews are conducted whenever specifications change.

Reliability reviews for concurrence all design specification/drawings prior to their release. This review ensures that the set of specifications/drawings covers all items of the SSME hardware at the appropriate levels, that each is complete in its contents and is functionally and physically consistent with interfacing design specifications.

In addition, Reliability examines all design changes for their effect on FMEA/CIL and supports the product teams in preparation of the ECPs by supplying reliability analyses and failure histories as applicable.

Malfunctions related to design testing and certification are reported to Reliability Engineering in accordance with the requirements of Space Shuttle Main Engine, Reliability Data Reporting Requirements RF0004-004.

2. TRADE STUDIES

Growth & Life Analysis

Reliability originates analyses or participates in studies originated by other engineering functions. These studies include the investigation of reliability growth/degradation and initiation of statistical methods used in the analysis of data for establishing life limits of time sensitive reusable components. These studies are often performed on a consulting basis and tailored to the specific issue(s).

Reliability Analysis

Reliability participates in analysis and assessment of SSME system and components failure risks. These analyses include component, subsystem, and system failure probabilities, launch abort, engine shutdown and single flight reliability, and failure investigation/resolution support.

Probabilistic Analysis

The Reliability function works in conjunction with Design Technology, Suppliers, and other Engineering functions to develop probabilistic methods and analytical techniques to support engineering, manufacturing, and quality issues. These analyses include Probabilistic Design/Analysis support, manufacturing and inspection capability assessments, and engineering analysis support. These analyses will serve to identify statistical process needs as well as process improvements.

3. FAILURE MODE AND EFFECT ANALYSIS AND CRITICAL ITEMS LIST

General Requirements

The FMEA/CIL effort is the responsibility of the SSME Vice President and Program Manager. FMEAKIL will be prepared in accordance with requirements contained in MSFC Document EG5320.1, "Space Shuttle Failure Mode and Effect Analysis and Critical Items List Ground Rules," including Appendixes A and B, dated 17 December 1986. The process of generating and revising FMEA/CIL's is described in detail in the section below titled, "FMEAKIL Generation and Revision Process Flow."

The ground rules provide classification, definition, and FMEA requirements in regard to certain systems, hardware, interfaces, and mission phases. The FMEA identifies component failure modes, categorizes each failure mode according to its worst-case failure effect, identifies possible failure mode cause(s), and assesses the failure effect on the engine, vehicle and mission.

Maior Subcontractor FMEAKIL Coordination

Honeywell, Inc., in accordance with applicable DRs prepares it own FMEA on the Controller, which is submitted to Rocketdyne for review. The Honeywell FMEA provides a detailed analysis on the functional elements of the Controller. The Controller FMEA analysis is divided into the following six volumes: Introduction and Concerns, Digital Computer Unit, Computer Interface Electronics, Input Electronics, Output Electronics, and Power Supply Electronics. Rocketdyne reviews the Honeywell FMEA for failure modes which may affect the engine or mission. The specific causes associated with these failure modes are referenced in the Rocketdyne FMEA. The Rocketdyne CIL provides rationale of retention for the design, inspection and test for the Controller.

The FMEA for the Hydraulic Actuation System is prepared by Rocketdyne and submitted to Hydraulic Research for review and comment. The integrated results of both analyses are incorporated into Rocketdyne's FMEA.

Government-Furnished Equipment

Pratt & Whitney, in accordance with the applicable DR, prepares its own FMEA on Pratt & Whitney Alternate Turbopump, which is reviewed by Rocketdyne. The Pratt & Whitney FMEA is performed at the functional level identifying piece part causes for critical failure modes. The Pratt & Whitney FMEAKIL contain all data elements as required by the applicable DRs. The NASA-approved Pratt & Whitney FMEAKIL are integrated into the Rocketdyne SSME FMEA/CIL document. Integration related hardware changes for the alternate turbopump are analyzed by Rocketdyne, and the associated FMEAKIL are documented.

FMEA / CIL Interfaces

The FMEA is conducted in conjunction with Engineering; thus problems requiring Engineering action are immediately brought to their attention.

The results of tests run during development and/or production engine-acceptance are reviewed to discover any new failure modes not anticipated in the initial analysis, and to ensure that all credible modes of failure and their effects are covered in the FMEA/CIL. MCRs, ECPs, DARs, and NCNs are also reviewed to ensure that any changes to the approved engine configuration or systems are factored into the analysis.

The FMEA/CIL supports Quality Assurance in preparing inspection plans, classification of characteristics, and implementation of procurement controls (Ref. SSME Quality Program Plan, RSS-8503-7). The FMEA supports the SSME System Safety Organization in preparing hazard analyses (Ref. SSME System Safety Plan, RSS-8503-S). The FMEA supports maintainability programs in defining maintenance actions, methods of detecting impending malfunctions, and ensuring that the techniques of maintenance are reflected in the design (Ref. Operational and Flight Support Plan, RSS-8503-5).

a. Failure Mode and Effect Analysis Requirements

DR RA- 145-2 establishes the requirement for the preparation of the SSME FMEA. The FMEA report is maintained in accordance with the instructions and ground rules contained in NSTS 22206.

The FMEA identifies component failure modes, categorizes each failure mode according to its worst-case failure effect, identifies possible failure mode cause(s), and assesses the failure effect on the engine, vehicle and mission.

The FMEA also contains the following elements: engine system/subsystem descriptions, indices, coded system block diagrams, phase and sequence diagrams, ground rules and assumptions, configurations, a component coding system, and schematics and figures as necessary to aid in the description of each component or system.

The FMEA considers the function of each component and its applicable failure modes for each operational phase of the engine, beginning with propellant loading of the vehicle and ending with propellant dumping.

The failure modes in each operational phase are evaluated for effect on the mission and are categorized according to criticality. Failure mode criticality is based on severity of worst-case effects of component failure in relation to crew safety, vehicle and mission.

Criticality (CRIT)	Category Definitions
1	Catastrophic engine failure resulting in the loss of life or vehicle.
1R	Redundant hardware/element failure that could cause catastrophic engine failure resulting in the loss of life or vehicle. Failure resulting in... · Premature engine shutdown after liftoff · Engine hydraulic or electrical lockup · Off-nominal engine performance Hardware failure that would result in crit 1 failure if protection function (redline, Emergency Shutdown Limit monitoring, or loss of Major Component Failure Protection) failed. Failure of function protecting against crit 1 failure
3	All others

b. Critical Items List Requirements

DR RA-145-9 establishes the requirements for the preparation of the SSME CIL. The CIL report will be maintained in accordance with the instructions and ground rules contained in NSTS 22206.

The CIL identifies all SSME critical items and provides rationale for their retention. The CIL is to be generated from failure mode and effect analysis data presented in the FMEA. The FMEA identifies all potential critical hardware failures and causes for critical failure modes. For every critical failure mode, there will be an applicable CIL containing the risk retention rationale. The CIL will also provide redundancy screen information for critical redundant items as applicable. This information will serve as a basis for preparation and submittal of redundancy screen waivers for Level II requirements.

c. FMEAKIL Generation and Revision Process Flow

ECP's, MCR's, RCN's, DAR's, NCN's, and UCR's are reviewed for impact to the FMEAKIL. Any of these documents may effect a change of the FMEAKIL. The process flow for the generation of and the revision to the FMEAKIL is shown by Figure 3-2.

FMEA/CIL GENERATION & REVISION PROCESS FLOW

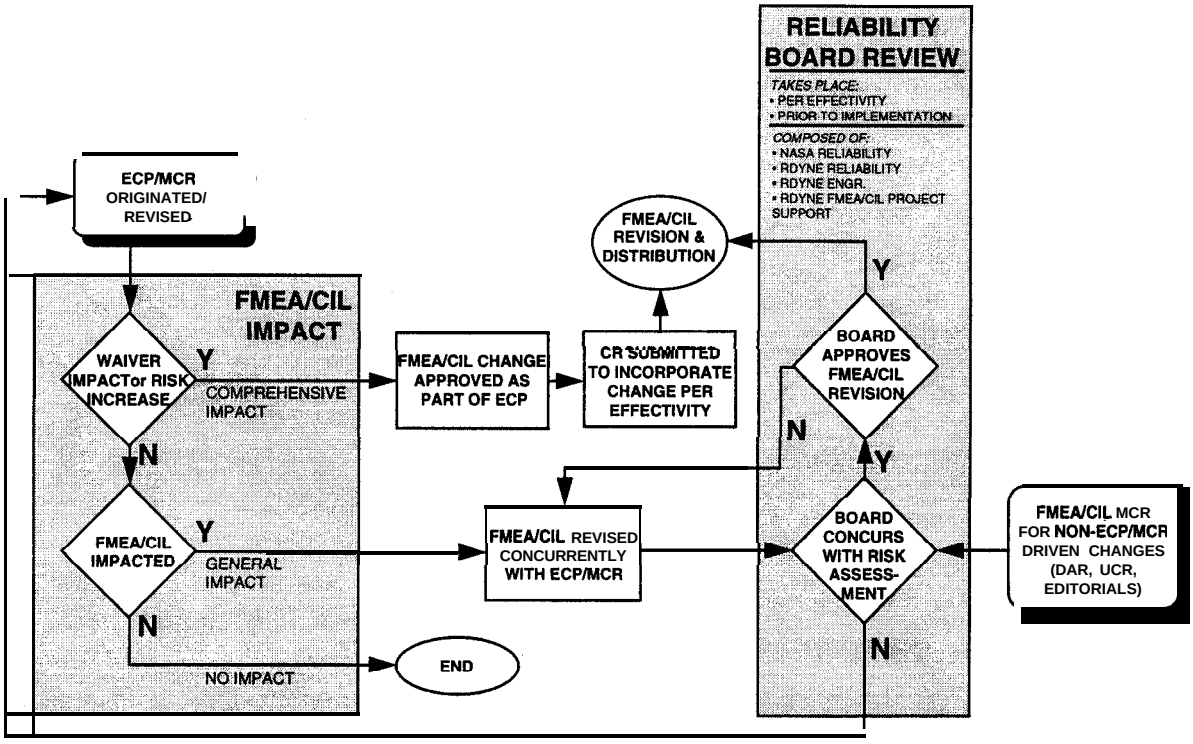

Figure 3-2

A FMEA/CIL generation or revision is initiated in response to design, inspection, or test changes, or for the purpose of making editorial changes.

All design, inspection, or test changes are reviewed and evaluated for FMEA/CIL impact by Rocketdyne S&MA prior to being submitted formally into the document approval cycle. An impact statement package is generated and attached to the design change. Impact statements fall into one of three categories: comprehensive, general, or no impact.

Comprehensive impacts (for those design changes that impact waiver or increase risk) will be reassessed after ECP approval but prior to ECP effectivity for changes that may have resulted from the evolution of the ECP. Those impact statements that must be changed will be evaluated by a Reliability Board (composed of NASA Reliability, Rocketdyne Reliability, and Rocketdyne Engineering) for risk change (a positive risk change forces a revision to the design change document). Ultimately, all comprehensive impacts result in a Change Request submitted to NASA, acceptance of which results in FMEA/CIL revision and distribution.

General impacts result in the Reliability Board review of the proposed FMEA/CIL change risk assessment after the ECP/MCR has been approved. Rejection by the Board forces a revision to the design change document. Acceptance results in FMEAKIL revision and distribution (no Change Request is required).
Impact statements that fall into the "No Impact" category have no affect on the FMEAKIL and are maintained for documentation purposes only.

Editorial changes to the FMEAKIL (to correct typographical errors, formatting errors, etc.) will be incorporated by MCR. This editorial MCR will be submitted directly to the Reliability Board and handled from that point forward in the same manner as changes that result in general FMEAKIL impacts.

d. FMEAKIL Implementation

The CIL Implementation System (CIS) is an information system for the identification and control of FMEAKIL rationale which includes critical inspection points of the SSME Program. It also assures that basic Engineering, Procurement, Manufacturing, Quality, Test, and related functions integrate the critical nature of the CIL items into their respective basic activities. The system defines the critical inspection and tests, as established by the CIL retention rationale, and provides identification to engineering requirements and implementation documents. In addition, changes which may impact the retention rationale are controlled, evaluated, and approved by appropriate Rocketdyne and government personnel.

The CIS utilizes existing functional procedures to support compliance with contractual requirements (see Table 3-l). Procedures for the assessment of changes to the CIL retention rationale are contained in PB96-008, Engineering Change Control, and PB96-017, Approval of Deviations and Waivers. Procedures for Classification of Characteristics (C of C) are defined in PB96-057.

The system was developed around a computer database that categorizes design features in terms of their criticality for safe and successful engine operation, and relays the quality requirements to applicable inspection organizations. These categories are based on the C of C, and provide the basis for determining the inspection levels required to provide confidence in the design features. The requirements defined in the CIS database are identified in the working level documents for manufacturing, test, and operational functions.

Table 3-1. CIS Functional Procedures and Contractual Requirements

FMEAKIL Contractual and Procedural Requirements		
CIL Implementation Requirements	**Procedure Providing Contractual Coverage**	
	Number	**Title**
Approval of Deviations and Waivers	RSOP 13.1 PB96-017	Material Review Approval of Deviations and Waivers
Assessment of Changes to CIL Retention Rationale	PB96-008 PB96-029	Engineering Change Control Master Change Record
Identification of Critical Inspection and Test	PB96-057	Classification of Characteristics
Major Subcontractors and Suppliers	RSOP 5.2	Control of Supplier Data

(1) Classification of Characteristics

The C of C is utilized by Rocketdyne as a means of identifying and communicating design information considered essential to product performance. Product performance characteristics are classified by utilizing analysis that considers the function, performance, interchangeability, and service life requirements. The analysis encompasses material properties, factors of safety, fracture mechanics, tolerance studies, CIL redundancy screens and design retention rationale, failure modes and the effects of failure on performance and safety. Characteristics are classified as follows.

Critical Characteristics: Inspection and Tests defined in the SSME FMEAKIL that represent the final level of verification(s) necessary to minimize the probability of failure. Critical characteristics are those features that, if outside prescribed limits, are likely to cause hazardous or unsafe conditions that could result in loss of life, vehicle, or mission. These characteristics require 100% inspection with recording of inspection results as determined by Quality Engineering.

Primary Characteristics: Inspection and Tests, including those defined in the SSME FMEAKIL, which represent component or detail level in process verification(s) necessary to minimize the probability of failure. Primary characteristics are those features that, if outside prescribed limits, are likely to result in loss of performance of the SSME, resulting in hazardous or unsafe conditions.

Maior Characteristics: Design features that, if outside prescribed limits, are likely to degrade the performance of the SSME.

(2) CIS Database

This CIS database is an automated system that links the FMEAKIL, engineering requirements, and applicable implementing documents. The system is a relational database established from part specific C of C. The database provides for the

information to be accessed and organized into a variety of report formats including: Classification of Characteristics worksheets, Field Site Requirements (FSR) worksheets, Procurements Inspection Plans, CIL Data Requirements tables, Defense Procurement Resident Office Activity Guide Lists, and Inspection Checklists. The CIS database is maintained on a Local Area Network computer system. A "Read Only" version is available on the LAN system allowing access to the CIS data by all applicable organizations.

(3) **Implementation**

FMEA/CIL and classification of characteristics data is transmitted to all applicable organizations utilizing the CIS database. The report formats listed in paragraph c.(2) provide the linkage of the CIL and engineering requirements to the applicable manufacturing, test, and operation documents. Quality Assurance personnel at Rocketdyne, Stennis Space Center, and Kennedy Space Center access the CIS database for identification of the CIL inspection and test requirements for incorporation into applicable working level documents including: Manufacturing Operation Records and CIL data requirements used to control Rocketdyne manufacturing and supplier requirements; Engineering Instructions and FSR worksheets used to control SSC test operations; and FSR worksheets and Operations and Maintenance Requirements and Specifications Documents used to control KSC flight operations.

e. GSE FMEA and CIL Preparation

The system safety analysis for SSME ground support equipment has been modified to include criticality assignments and waiver processing. The system safety analysis includes failure investigation and rationale for retention for critical GSE hardware per document RSS-854522, Volume II, SSME Integrated Hazard Analysis for Ground Support Equipment.

4. RELIABILITY-MAINTAINABILITY

a. Maintainability Interface

The Reliability Function interfaces with Logistics in referencing maintainability through the SSME Operational Logistics Support Plan (RSS-8670) and the Logistics Supply/Support Plan (RSS-8665), which includes design reviews, trade studies and the review and approval of design change and deviation documents.

b. Tracking Limited Life Items

Rocketdyne Reliability reviews, identifies, documents, and statuses limited life items through DARs, Non-Flight Limitations, Nonconformance Notices, and Limited Life Tracking Document (RLO0532) for validity of life limits and Reliability impact on SSME hardware. This customer-approved system provides for the replacement or refurbishment of hardware after a specified age or operating time/cycle.

5. DESIGN REVIEW AND READINESS REVIEW

Reliability reviews all design changes to assure compliance with the existing reliability requirements for the new design in sufficient depth to identify and resolve potential problems prior to Engineering release to Manufacturing. Procedure implementation responsibility for design review is defined by the SSME Configuration Management Plan and applicable RSOPs. The Design Review Checklist for the Reliability function addresses key issues pertaining to FMEA/CIL impacts, reliability degradation, etc. and is the key to documenting reliability concerns.

Reliability provides UCR and FMEA/CIL input as applicable to all FRRs. In addition, Reliability participates in FRRs to assure accurate presentation of all associated reliability data.

6 PROBLEM REPORTING AND CORRECTIVE ACTION

Rocketdyne maintains a closed loop Problem Reporting Analysis and Corrective Action system which consists of a UCR and FAR.

Rocketdyne's major subcontractors, Honeywell, HR Textron, and Pratt & Whitney (post DD250's) are required to employ a problem/failure reporting system similar to Rocketdyne's for those failures that occur at their facilities, and to assist Rocketdyne with failure analysis on their hardware that fails during engine level testing. Items which meet the requirements of a UCR will be entered into the UCR system, either by the subcontractor or responsible Rocketdyne Reliability Engineer.

The PRAMS is a computerized database in which both the UCR and FAR are documented. The system maintains documentation related to the problem and provides the capabilities for tracking and retrieving information, electronic routing and signatures, and an automated electronic data transfer from Rocketdyne to the NASA Problem Reporting and Corrective Action System. Related documents (i.e., figure pages, IDCRs, PRs, tables, etc.) are maintained and accessible in central files. Reliability is responsible for providing assistance and training personnel in the usage of PRAMS and maintaining the tables of codes.

a. Problem Reporting

The UCR system is intended to document any reportable problems as defined by the SSME Reliability Data Reporting Requirements Specification, RF0004-004 on production, development, and certification hardware. The RF0004-004 is submitted for concurrence under Data Requirement RA-145-1, Reliability Specification.

b. Problem Analysis

A FAR is required to answer every UCR that has been entered into the database. The team responsible for problem closure shall be determined by Reliability. The FAR assignee will ensure that remedial action has taken place, perform failure analysis, and assure recurrence controls have been coordinated with the responsible organizations.

c. Problem Resolution

All FARs require recurrence control or rationale as to why recurrence control is not necessary. FAR closures will be reviewed and approved by Rocketdyne and MSFC management prior to final closure.

d. GSE Problem Analysis and Resolution

UCRs shall be written on malfunctions occurring on GSE interfacing with flight hardware. Problem Analysis and Resolution shall be performed as outlined in the Problem Analysis and Problem Resolution sections above.

e. Problem Status

The status of open UCRs/FARs is tracked by SSME Reliability to ensure that no flight constraints exist.

7. REPORTING AND RESOLVING NASA PARTS MATERIALS PROBLEMS (ALERTS)

Rocketdyne participates in the NASA ALERT System by reporting and responding to parts, materials, processes, and safety problems of mutual concern to Rocketdyne and its subcontractors, NASA, and associated contractors. The Rocketdyne ALERT Program is implemented by applicable quality procedures. The Government-Industry Data Exchange Program (GIDEP) administrator receives ALERTS and provides written responses, as required.

a. Investigation

All ALERTS received are investigated to determine applicability to SSME or related GSE hardware. These investigations are conducted through research and evaluation efforts of engineering configuration requirements, as well as through reviews of procurement databases to determine supplier utilization.

b. Remedial Action/Resolution

Any nonconformance found as a result of an ALERT investigation will be documented and submitted to Rocketdyne's Material Review process, or problem reporting system according to RF0004-004. All hardware, including GSE, affected at Rocketdyne or in the field will be placed on hold pending remedial action or resolution through the material review process and/or problem reporting analysis and corrective action system. Utilizing PRAMS for evaluation and administration purposes assures Rocketdyne of a closed-loop system.

c. Response

Verbal response to ALERTS is provided to MSFC within 48 hours of ALERT receipt, followed by an interim written response within 7 calendar days. Final response is due within 14 calendar days except as required due to launch schedules. The resolution and/or response shall include remedial action taken to address any issues of significant impact on Quality, Reliability, and recurrence control measures.

d. Contractor Initiated ALERTS

When the contractor encounters a significant problem with a part or material that may adversely affect equipment, the contractor may initiate an ALERT and submit it to the MSFC ALERT coordinator. The contractor shall not release an ALERT without prior MSFC approval.

e. Integration of GIDEP System

The integration of the GIDEP system into the PRAMS Program permits in-house automation of GIDEP and Marshall ALERTS, status reporting, trending history, customer access for perusal of abbreviated ALERT descriptions, and provides a more rapid response mechanism to MSFC on NASA TWX ALERTS and GIDEP Full ALERTS.

8. ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL PARTS AND MECHANICAL PARTS CONTROL

The Rocketdyne Aerospace Support Equipment parts manual provides a listing of the standard hardware suitable for use on SSME and satisfies the applicable data requirements assigned to appropriate product team. Parts are grouped by their physical, mechanical, and material properties and arranged in order of precedence specified in MIL-STD-975 (DOD); Electrical, Electronic, and Electromechanical parts selection, NASA document MSFC 85M03928.

Requirements for control of nonstandard parts are included per applicable Rocketdyne drawings and specifications in accordance with MSFC Document 85M03928. Reliability evaluates the new nonstandard hardware and associated design characteristics during design reviews and ECP reviews. Changes to these requirements are processed via MCR and approved by Rocketdyne Reliability Engineering. Non-Standard Parts Approval Requests are processed and approved by Rocketdyne Design Engineering per NASA Document MSFC 85M03928. Only parts embodying proven technologies and having established qualifications will be utilized.

9. MATERIALS SPECIFICATIONS AND APPLICATION REVIEWS

Rocketdyne ensures proper application of all parts, devices, and materials as follows: examine the application in light of its rated capabilities compared to the design requirements of the application, anticipated life requirements, functional and environmental usage stresses, and historical and current failure experience.

1D302 TESTING

1. CERTIFICATION

Rocketdyne Reliability monitors and supports the certification program through design reviews, MCRs, ECPs, and Verification Complete Reports. Hot-fire malfunctions related to design testing and certification, as well as any new Design Verification Specification programs, are reported to Reliability in accordance with the requirements of Reliability specification RF0004-004.

2. ACCEPTANCE TESTING

The Reliability function participates in Pretest Data Reviews. Functional acceptance testing is conducted by Manufacturing at the Canoga Facilities and hot-fire acceptance testing is performed at Field Test Sites. Rocketdyne Reliability coordinates the closure of all open unsatisfactory conditions with remedial action and recurrence control.